5. Shrimp production trends and demand analysis

5.1. Introduction

This section of the final report on the shrimp management project summarises the findings of an economic study into trends in production, markets and in supply and demand for shrimp. The full text of the report of this study is appended.

2,443,300 metric tonnes of tropical and cold-water shrimp were placed on the world market in 1989. Tropical catches and aquaculture production accounted for approximately 1,700,000 MT and 565,000 MT respectively, with approximately 200,000 MT of cold-water shrimp being landed.

In value terms, with imports currently in excess of $US 4.4 billion, shrimp account for approximately 20 per cent of the total world trade in fisheries products. Direction of trade is dominated by developing country exports, which supplies around 90 percent of total shrimp imports by industrial countries.

For many developing countries the shrimp production sector, which includes both aquaculture and capture fisheries, is an important source of foreign exchange earnings through exports. Furthermore it is a sector which can generate and sustain primary and secondary rural employment.

The past decade has been characterised by heavy investment in shrimp aquaculture. Although the potential return from aquaculture is still attracting investment, greater competition amongst producers and more pronounced volatility in international market prices due to increasing production levels is a potential concern amongst private investors and policy makers in the aquaculture sector.

However, the differences in production costs both within and between the competing capture and aquaculture sectors means that any fiscal or financial policy addressing the cost or level of production in one sector must also consider possible impacts on the economic performance in the other. Levels of employment and investment may be altered, as well as methods of production in each of the sectors. Therefore this is an important issue for development strategists in understanding the implications of any policy in the light of present and future market conditions.

This study focuses on how changes in market price and quantity demanded due to increased aquaculture production will impact upon revenues and employment, and hence fishing methods, within the shrimp capture fishery industry. Several processes may affect price and quantity demanded, with the important issues being identified as follows:

i Given the probable increases in the level of shrimp production, especially from aquaculture sources, the first issue concerns the effect that overall increases in supply will have on market prices. A related issue is the impact that changes in consumer expenditure may have on overall demand for shrimp.

ii A second issue stems from the likelihood that any increases in production will come from aquaculture and therefore, given current production strategies, consist of medium sized shrimp. Of interest is the possible impact that an increase in supply of medium size categories will have on the price and quantity demanded of other size categories.

The possible changes in market price and quantity demanded which cause concern at the macro-economic level can only be resolved by analysing micro-economic issues using the tool of demand analysis to determine a demand function and relevant elasticities.

Estimates of both price and income elasticity of demand can be used to identify any relationship between total quantity of shrimp consumed, changes in the price of shrimp and consumer income levels. Estimates of own and cross-price elasticities of demand for the different size categories of shrimp can be used to identify the direction and magnitude of any price-quantity interactions between the different size categories. These estimated income, own and cross-price elasticities, combined with future production scenarios for a specific sector, allows the direction and magnitude of changes in market share, prices and quantity demanded to be quantified. From this information, future revenues can be determined and the implications for employment and methods of production in each sector discussed.

The own-price elasticity of demand for a good, in this case shrimp, is a measure of the magnitude of change in price brought about by a change in quantity demanded of that good. If a change in price brings about a less than proportionate change in quantity demanded then the good is said to be inelastic (elasticity less than one). In this case, total revenues rise when the price rises. On the other hand, demand is considered elastic when a change in price causes a more than proportionate change in quantity demanded. In this case total revenues rise when price falls and falls when price rises. Cross-price elasticities relate the change in demand brought about in one good by the change in price in another good, or vice versa. Income elasticity is a measure of the change in price or demand of a good due to a change in income.

The strategy normally adopted for the estimation of an aggregative demand function for generic shrimp species which uses some measure of income and relative price is not sufficient to satisfy the aims of this report, which include the estimation of cross-price elasticities. Thus an alternative approach using a disaggregated model which looks at the relationships between the different size categories of shrimp in markets is utilised. This disaggregated demand analysis approach estimates the values of the income, own and cross-price elasticities of different sized shrimp.

Being inextricably linked, data limitations may constrain the model specifications, and model specifications in turn have strong implications on the data requirements. Knowledge of the "institutional realities" of the specific industry and environment within which is operating is important in the decision over the appropriate data, data period (weekly, monthly, quarterly or annually) and model specification (linear, non-linear, aggregated or disaggregated, quantity or price exogenous).

Thus the first requirement of any demand analysis for a particular commodity is to identify the special characteristics of the market involved in order to arrive at a suitable specification for the demand equation, given the aims of the demand analysis. A general description of the global shrimp market identifying the principal characteristics of each of the main markets (the U.S.; Japan and Europe), including price and consumption trends is presented. The most common product forms, their market segments and the direction of trade, including volumes to provide some indication of the importance of different suppliers, are also discussed. A brief review is made of the major sources of production of Penaeid shrimp species, describing the general historical trends in production from both capture fisheries and aquaculture. More information on market structure is introduced by reviewing the results and main points of published aggregate demand analyses of shrimp demand.

Based on the information collected by the above approaches, the disaggregated demand analysis is initiated. Acknowledging that data availability has been a limiting factor on model specification in nearly all past seafood demand and market analyses, the availability of disaggregated data for modelling the shrimp market is described. For the purposes of this report, the only publicly available sufficiently detailed disaggregated data is that provided for part of the US market by the National Marine Fisheries Service (NMFS).

A qualitative demand analysis of the US market is carried out, US market characteristics which may be significant in the demand and supply interaction as identified in the description of the US market are summarised and restrictions on which factors can be included in the demand model due to data availability are discussed.

In addition to data restrictions and requirements, demand studies for fisheries products have created a debate among economists with respect to the degree to which price or quantity is

considered exogenous. Conventional empirical demand systems normally take prices to be exogenous and use price, together with income and substitute effects, to determine the quantities demanded. Implicit in this approach, described as "quantity-dependent", is the assumption that supply is perfectly elastic in the region of the prices being considered and that the price a supplier is willing to accept for a given quantity is determined outside the market by cost factors such as production and transport.

An alternative approach, termed "price-dependent", arises when supply is inelastic and the quantity demanded is constrained. At the individual consumer or supplier level the "quantity-dependent" approach is applied, provided the individual consumers and suppliers are price takers. However, at the market level, if supply is inelastic, prices will alter until the quantity demanded is equal to the quantity supplied. This leads to quantity being considered as exogenous.

The two approaches outlined above are the two extremes of a continuum in which the degree to which either price or quantity is exogenous varies. For instance, demand for wet fish in Great Britain appears to be modelled more convincingly using the "price-dependent" approach. Given that virtually all of the wet fish supplied to the U.K. market is from capture fisheries with catch quotas, and that there is little leeway for storage of the given product form, it is perhaps unsurprising that quantity is exogenous at a market level. However, the structure of the world shrimp market is quite different, with aquaculture production and cold storage facilities introducing considerable flexibility to the supply. The two extremes were therefore tested in section 4 using the standard log-log static linear demand model.

Another area of demand analysis in which debate has arisen regards the functional form of the demand function. The use of the standard log-log static linear demand model imposes strong assumptions on the underlying structure of demand. A generalised choice model, which relaxes constraints on demand structure, is thus also applied.

Given a known initial price and a speculated change in supply, the estimated own-price, cross-price and market share elasticities for the different size categories of shrimp can be used to determine the future prices of each of the size categories. Published predictions of future shrimp production from both aquaculture and capture fishery sources are assessed to determine likely future production scenarios to be used in predicting price changes. Data limitations leading to low precision in estimated elasticities precluded future prices being predicted quantitatively, but production costs were described and the possible impacts with respect to shrimp prices, methods of production, total revenue and employment within the capture fisheries sector are described qualitatively.

Overall conclusions from the study are summarised and recommendations are made on the basis of these conclusions.

Due to disaggregated data restrictions for domestic US shrimp production, the size categories of shrimp were defined as follows:

Large shrimp	=	up to 25 count/lb.
Medium shrimp	=	26 to 50 count/lb.
Small shrimp	=	over 51 count/lb.

5.2. Description of Shrimp Markets

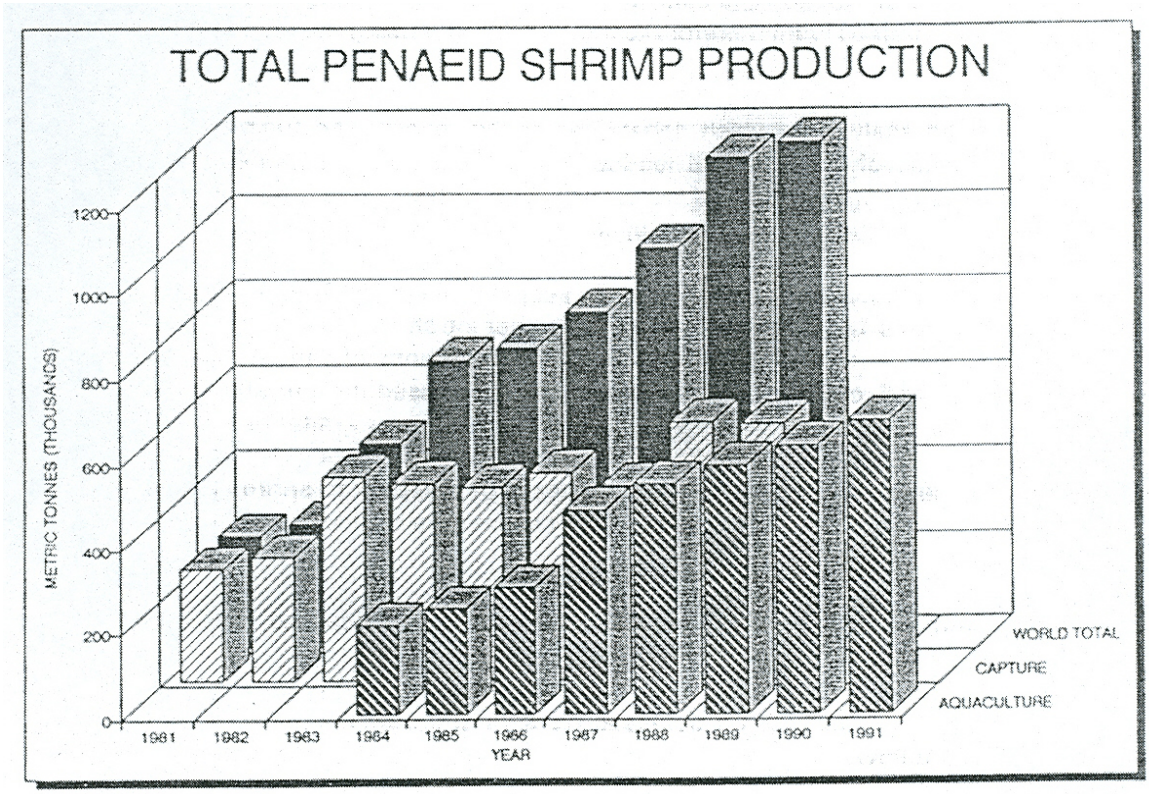
The aim of describing the shrimp market structure is to provide the basis upon which the likely significant factors to be used in the supply and demand relationship can be determined.

The analysis of current directions and volumes of trade reveals that there are three major import markets for tropical shrimp species; Japan, the USA and Europe. Total volumes of shrimp imports to each of the three markets increased dramatically during the 1980s, with tropical shrimp from developing countries now accounting for approximately 80% of total imports. Traditional supplier and distribution patterns are being eroded under the forces of market competition and changing consumer behaviour with a concentration in the supplier countries base being evident.

Increased consumption of domestically produced shrimp by the developing countries themselves during the early 1990s is further altering the patterns seen in the 1980s.

The review of major sources reveals the lack of potential for large increases in capture fishery production and the dramatic increases in aquaculture production during the 1980s and early 1990s as shown in figure 1.

Figure 1: Total Penaeid Shrimp Production



Source: FAO Fisheries Statistics and World Shrimp Farming

However, limiting factors, some of which, such as environmental degradation and seed problems, have already been manifested, suggest that the explosive growth of aquaculture production is unlikely to continue. The potential for future production from aquaculture is returned to later.

A description of product forms indicates that shrimp are sold by size, which is the primary factor in determining market segment, although traders also categorize according to colour and country of origin, and product form will vary depending on the market into which the shrimp is being sold.

The following shrimp product forms are regularly offered to the markets:

i Live shrimp. This product has a limited market and commands very high prices.

ii Fresh shrimp. This is usually a product which is restricted to domestic markets within easy reach of the landing sites. There is a limited amount of international trade in this product.

iii Frozen shrimp. This is the most commonly internationally traded product form. This is usually reprocessed into a variety of other forms.

iv Canned shrimp.

v Dried shrimp.

Further differentiation in these five major product forms exists in order that the specific segments within the market can be targeted effectively. Headless shell-on shrimp are the most commonly traded product in the frozen form. Other forms include whole head-on, peeled and deveined (P&D), peeled and undeveined (PUD), breaded P&D, battered P&D, cooked and other regional speciality product forms. The import of cooked shrimp is currently low volume because of strict quality controls due to concerns over illness caused by *Listeria monocytogenes*. The 1990s are likely to see shifts in the markets for product types, particularly if the mobilisation of women within the work force increases as predicted for developing countries.

The targeting and increased relative production of value-added product forms is likely to be a necessity in the future as the shrimp market becomes increasingly more competitive. The importance of building up a reputable brand name is paramount, with virtually all shrimp being traded on the international market under a brand name. Producers use brand recognition to reinforce their reputations for consistent quality, uniformity and accurate counts.

Consumer preferences for colour and species of shrimp vary region by region within the US, Japan and Europe, and differ markedly between each of these markets. The commonly traded Penaeid shrimp species are shown in Table 1.

Table 1: Commonly Traded Penaeid Species.

SPECIES	COMMON NAME	COLOUR	ORIGIN
P. aztecus	Northern brown	Brown	Western Atlantic; Gulf of Mexico
P. brasiliensis	Redspotted	Pink	Western Atlantic (N. Carolina to Brazil)
P. indicus	Indian white	White	S.E. Asia; India; E. Africa; Madagascar
P. japonicus	Kuruma	White	S.E. Asia; India; China
P. merguiensis	Banana	White	S.E. Asia; India; Australia; Persian Gulf
P. monodon	Black tiger	Pink (cooked)	S.E. Asia; India; N. Australia; E. Africa
P. notialis	Southern pink	Pink	Eastern Atlantic (Mauritania to Angola); Western Atlantic (Mexico to Brazil)
P. occidentalis	Western white	White	Eastern Pacific (Mexico to Peru)
P. orientalis	Taisho	White	China; Korea
P. semisulcatus	Green tiger	White	India; S.E. Asia; E. Africa; Persian Gulf; Australia; Japan
P. vannamei	Whiteleg	White	Eastern Pacific (Mexico to Peru)

Source: Holthuis (1980); Rackowe (1984); Infofish Reports (1991/92).

Common in each market is the usage of large shrimp predominantly in up-market or specialist restaurants, medium shrimp in supermarkets and less exclusive restaurants, and small shrimp in cheap restaurants, shops and reprocessing. Price volatility in the Japanese market decreases with the size of shrimp being traded, perhaps due to both greater stability in supply of smaller sizes and lower demand elasticity.

Price volatility in the US market may also be due to recent departures from traditional distribution methods, with some producers attempting to cut out intermediaries in the distribution chain. There is price variation between species in the same market and between the major markets for the same species, indicating different consumer tastes. Concerns over the quality of imported shrimp also affects price, as reflected in the different prices for the same product depending on the country of origin.

Consumption in the US is seasonal, with some of this variation in demand being soaked up by inventory holding in cold storage. Consumption in each of the main markets increased during the 1980s, with European expansion being the most rapid and Japan the slowest. There are some indications that demand has reached an upper limit in Japan and is being approached in the US, and that there have been changes in consumption patterns in all of the main markets.

5.3. Review of Aggregate Demand Analyses

Previous aggregate demand analyses provide insights regarding market structure to be used when developing the disaggregated demand analysis model. Furthermore, previous results indicate the relative magnitudes that the various elasticities can be expected to have, and highlight the variation in estimates due to differing model specification and statistical analysis.

The results of three aggregate demand analyses are shown in table 2 below.

Table 2: Published Estimates of Price, Income and Cross Elasticities for Shrimp

AUTHOR	PRICE ELASTICITY	INCOME ELASTICITY	CROSS ELASTICITY	PERIOD	AREA
Bell 1976	-0.30	1.37		1947 - 1971	USA
Rackowe 1983	-0.19 -1.14	1.17 0.06		1960 - 1981 1972 - 1982	USA JAPAN
Yang 1992	-0.38 -0.36	0.99 1.25 1.5	0.53 0.35	1965 - 1988 1965 - 1988 1965 - 1988	USA JAPAN REST

The striking differences in the estimates obtained (i.e. estimates of income elasticities in Japan range from 0.06 to 1.25) may partly be due to different consumption and supply patterns in the different time periods, but are more probably caused by different model specifications.

Bell (1976) used a simple linear model whereas Yang (1992) used the standard log-log, static linear model. Only Yang (1992) found evidence that other seafood and beef were substitutes for shrimp.

In summary, and not accounting for the estimates from the analysis of the Japanese market by Rackowe (1983), aggregate demand analyses have identified shrimp as inelastic with respect to own-price and elastic with respect to income, with estimates ranging from -0.19 to -0.38, and from 1.00 to 1.37 respectively. This result is in agreement with a study by Globefish based on total disposable income and estimated supply of tropical shrimp to the US market (1969-1989), which determined that wholesale prices for headless shell-on shrimp are relatively more responsive to changes in income levels than changes in supply.

5.4. Demand Analysis: Disaggregated Models

Following on from the description of shrimp markets and aggregate demand analyses, disaggregated data was to be used to study the relationships between price and quantity of shrimp in each of the differing size categories and estimate own-price, cross-price and income elasticities.

Due to the limited availability of disaggregated data, this study was constrained in scope to modelling demand in the US, subject to certain assumptions. The National Marine Fisheries Service (NMFS) carries out an approximately weekly telephone survey of leading importers and distributors to determine quantities imported in each size category through certain US custom ports, wholesale prices in New York and Los Angeles and aggregate quantities imported from Mexico. The data thus collected is not a direct record of transactions in the market place, but does provide a view of market conditions. Until October 1989, this data was published in the NMFS New York Green Sheet market newsletter. More recent data is apparently still available (at a price) through a private publishing house.

Factors identified as relevant in determining the relationship between price and quantity in the US shrimp market include supply patterns, speculation using cold storage facilities, trading mechanisms, market segment, and consumer income. Due to the limited nature of suitable data, not all of these factors can be included in the disaggregated model.

The two most important components of shrimp supply to the US are imports and domestic production. The available data allowed three size categories to be used: large (up to 25 count/lb); medium (26 to 50 count/lb) and small (over 51 count/lb). Imports from Mexico and Ecuador are the most important components of US imports and are the most preferred by traders, but no size disaggregated data is available. Nearly all Mexican imports, which command a price premium in the US, enter the US market irrespective of price relative to other markets, indicating that trader preference and supplier flexibility affect the degree of exogeneity of price.

The quantities of shrimp held in cold storage in the US have declined since the 1970s with the increasing flexibility of supply due to aquaculture production, although speculation may still play a significant role in the movements of price and quantity for large shrimp which are supplied by capture fisheries. No disaggregated data is available describing quantities held in cold storage.

The attempt by certain suppliers to the US to sell direct to end users resulted in short term increased revenues for those suppliers but, due to the resulting confusion and drop in price for medium sized shrimp, this action would, if carried out by all suppliers, result in the long term in a drop in revenues.

Small shrimp enter reprocessing, retail and cheaper restaurant markets, medium sized shrimp enter medium priced restaurants, supermarkets and institutional markets and the larger sizes are used predominantly in the exclusive or specialist restaurant market. Qualitatively, the larger sizes seem to be perceived as luxury products having higher own price and income elasticities which makes them more susceptible to changes in own prices or quantities than smaller sizes, which are considered to be less elastic. However, the relative price stability exhibited by medium size categories may be due to the greater stability of supply of such sizes from aquaculture production.

There is a significant price differential between the large, medium and small sized shrimp, indicating that they are distinct products with different markets. Therefore general price or quantity changes in one size category are expected to have limited impact on the price or quantity demanded of other sizes. The use of three broad size categories may partly obscure interactions between narrower categories, both between and within the three wider categories. The level of disaggregation of US domestic production data prevented narrower size categories being used.

Figure 2a: Price and Quantity Trends for Large Shrimp

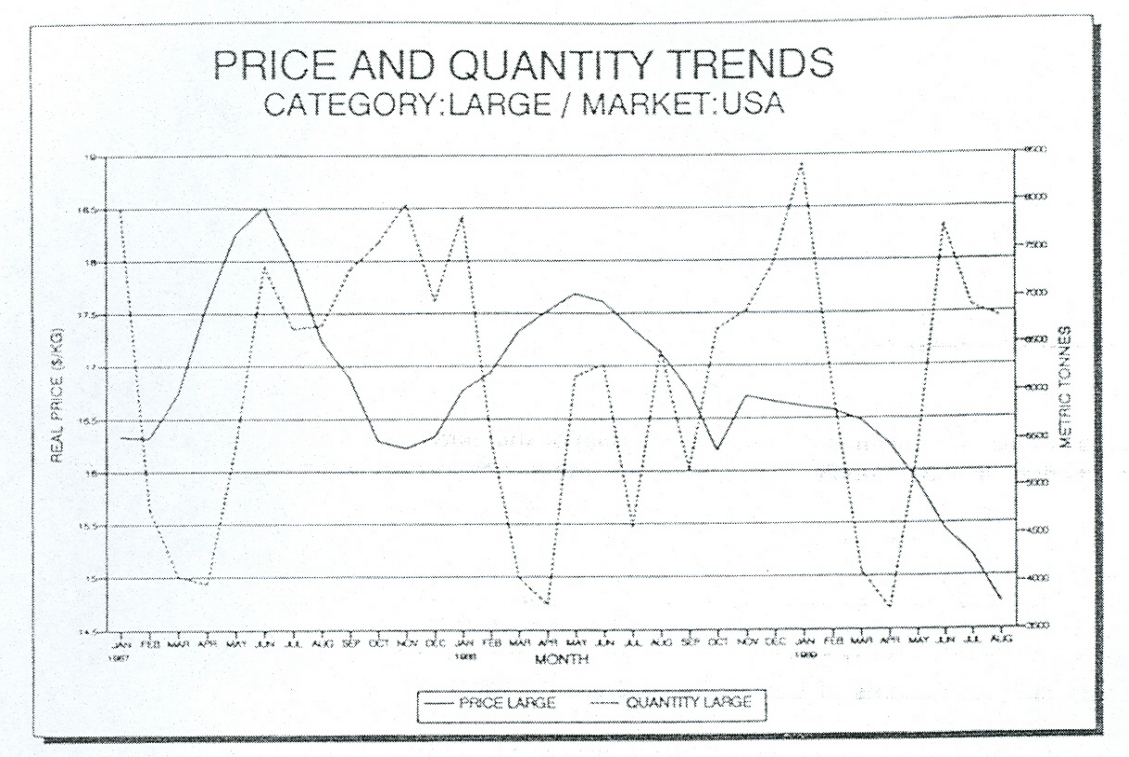


Figure 2b: Price and Quantity Trends for Medium Shrimp

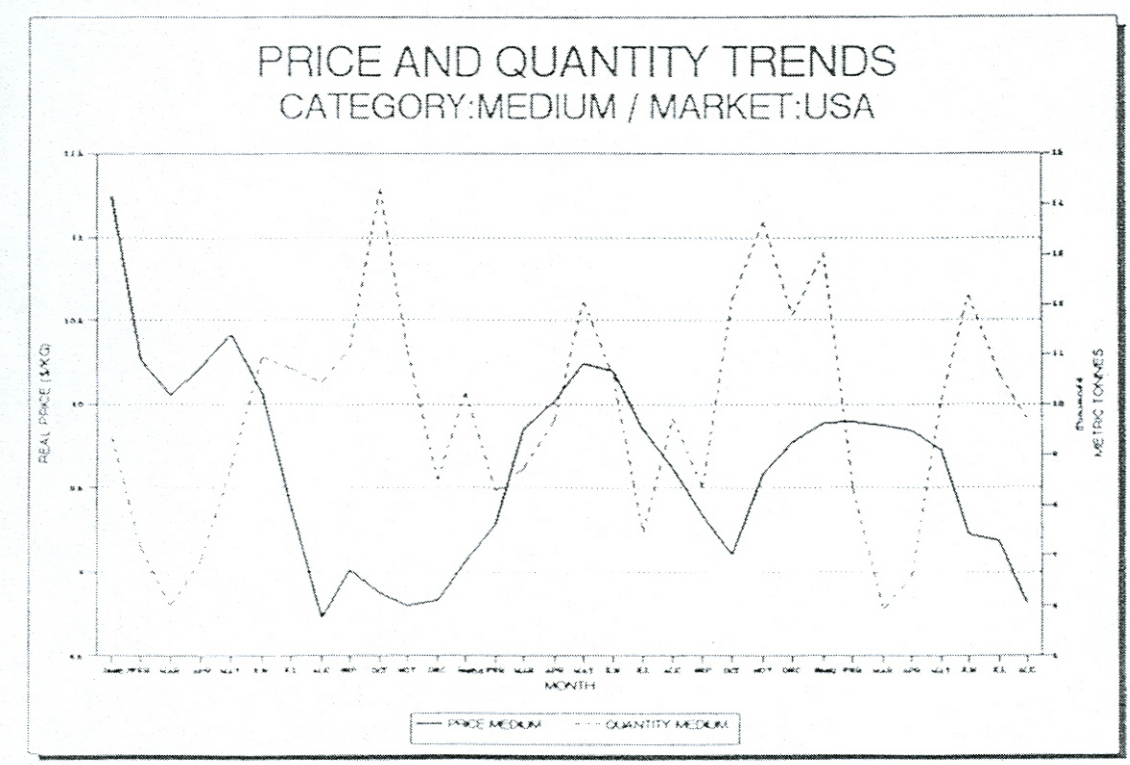


Figure 2c: Price and Quantity Trends for Small Shrimp

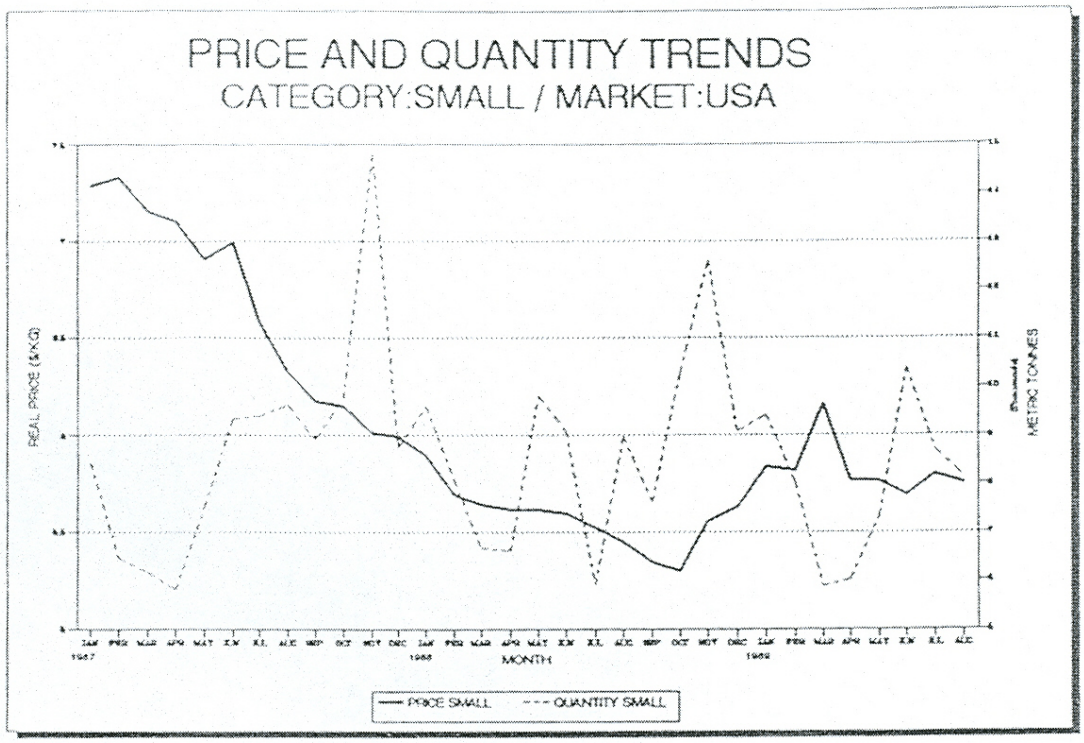
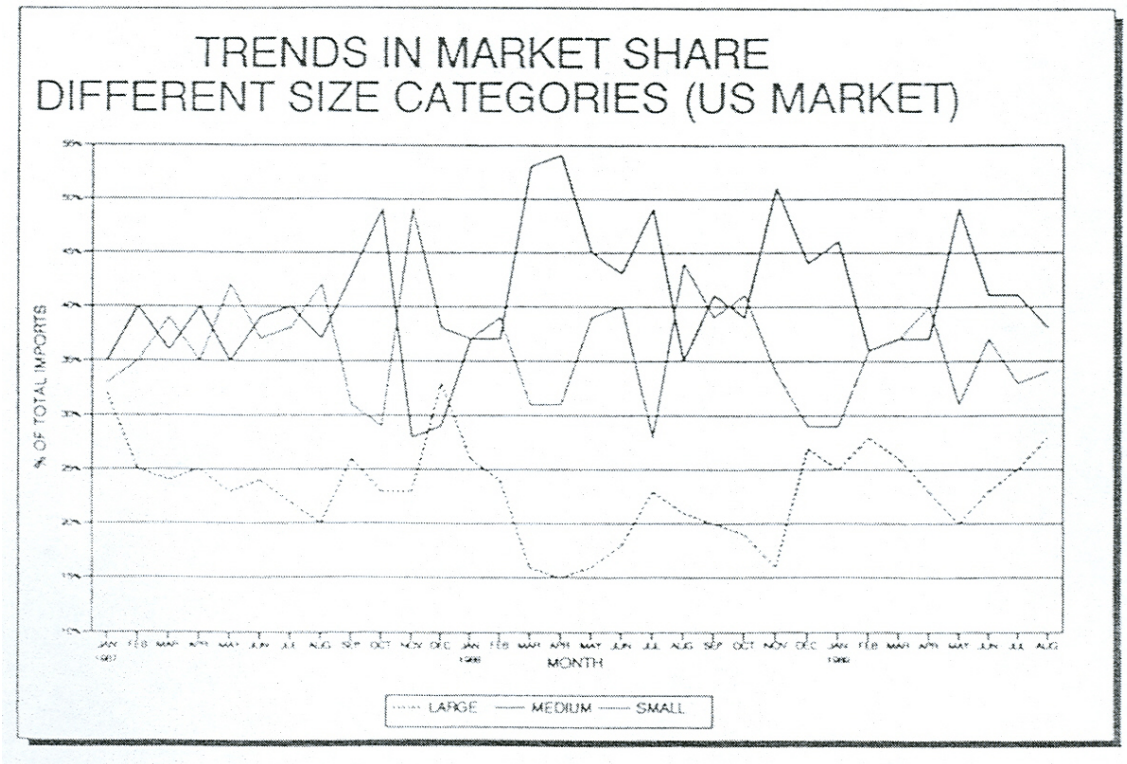


Figure 2d: Market Share Trends for Different Size Categories



The price and quantity trends for each of the aggregated large, medium and small size categories are illustrated in figures 2a to 2c, and trends in market share are shown in figure 2d. The large and medium size categories show relatively strong inverse relationships between price and quantity supplied to the market vis a vis imports. The trend for the small size category does not indicate a clear relationship between the two variables. Both the price and quantity of large and medium sizes follow a similar trends whereas the price of small shrimp fell steadily, failing to strengthen during 1988. The market shares of medium and small shrimp show a strong inverse relationship, but the market share of large shrimp does not relate in any simple manner to either medium or small market shares.

Apparent consumption of shrimp in the US market showed no clear relationship with per capita income, in contrast to the results of previous demand analyses described above.

The possibility that other seafood, meat or poultry are substitutes for shrimp cannot be discounted, especially as the proportion of shrimp entering the home consumption and fast food restaurant sectors increases, but at present there is no consensus on the role of substitution in the US shrimp market.

The limited availability of disaggregated data precludes all of the above factors from inclusion in the demand analysis, other than quantities imported, quantities produced domestically, the wholesale price of the different sizes, and income.

Given these variables, the demand analysis is effectively analysing the demand of traders in shrimp. The assumption that traders act as a proxy for the end consumer and therefore reflect the underlying demand is made. The more effective and skilful the traders are, the truer this assumption will be, although the trader market demand will not be a pure reflection of the end consumer market demand. Traders will take into account the expected seasonality of supply and try and predict price changes in other markets in order to exploit margins and make money. The range of factors which affect the decision of traders to purchase shrimp is wide, and, like a stock market, a large amount of buying is done on apparently irrational intuition. The lack of data on this feature means that there is a degree of uncertainty in choosing a suitable functional form for the demand function which will accurately capture the underlying consumer behaviour.

The simplest realistic model, the standard log-log static linear model, is presented initially, with both quantity and price exogenous specifications being used. Results showed that the "quantity dependent" (or price exogenous) approach gave elasticities more similar to those expected based on qualitative analysis, but that several inconsistencies were evident, due partly to the strong restrictions on the underlying consumer behaviour implied by the use of the log-log static linear model.

In order to relax restrictions on underlying consumer behaviour, alternative functional forms were considered. The generalized choice model, which relaxes restrictions placed on consumer behaviour and has an appropriate conceptual structure for consumption decisions based on qualitative analysis, was chosen. The general choice model assumes that a consumer (trader) decides on a level of shrimp consumption based on shrimp prices, prices of other goods and income. The consumer (trader) then chooses different amounts of different sizes so as to maximise his or her utility. This conceptual structure agrees well with the US shrimp market structure from a traders point of view. Individual consumers will not make choices in the manner described above when purchasing shrimp, but when consumers are aggregated and an average behaviour determined then the general choice model concept is appropriate. Underlying the assumption about the suitability of the general choice model is the assumption that the behaviour of traders is a good approximation to the average consumer behaviour. The model consists of an aggregate demand equation and a set of choice equations for the three size categories of shrimp. The results are shown in Table 3 below.

Table 3: Own-price and Cross-price Elasticities from the Generalised Choice Model

QUANTITY	PRICE (SMALL)	PRICE (MEDIUM)	PRICE (LARGE)
SIZE (SMALL)	-0.22 (0.27)	-0.38 (0.34)	-0.04 (0.35)
SIZE (MEDIUM)	-0.73 (0.65)	-0.34 (0.69)	0.16 (0.71)
SIZE (LARGE)	0.41 (0.25)	0.06 (0.30)	-1.15 (0.31)

The estimated elasticities shown in Table 3 appear plausible: most of the own and cross price elasticities have both the sign and approximate magnitude expected from the qualitative analysis. The own-price elasticity of demand for the individual size categories is estimated to be inelastic for small and medium shrimp at -0.22 and -0.34 respectively, and elastic at -1.15 for large shrimp. Also, medium and large shrimp are indicated to be substitutes.

However, several inconsistencies do remain. The cross-price elasticities between medium and small shrimp suggest that they are complements. However, qualitative analysis gives no indication that this should be the case. If anything, it is more likely that medium and small shrimp are weak substitutes. The two cross-price elasticity estimates between small and large shrimp are contradictory, with one estimate suggesting these two categories are strong substitutes, while the other suggests there is very little interaction between them. The latter estimate is much more plausible.

It should be noted, however, that any interpretation of these estimates must bear in mind their low precision. All the estimated parameters, other than the own-price elasticity for large shrimp, have large standard errors. There are several possible reasons for the low precision obtained. Particular problems are the assumptions required to extrapolate the size distribution of the NMFS imports sample to all US imports, the assumptions required to determine an average price for each size category given the complete lack of data on which countries of origin are supplying which species of shrimp within each size category, and the exclusion from the analysis, due to lack of data, of other factors identified as potentially relevant (see sections 4.2 and 4.3). In particular, the role that trader preference for certain countries of origin plays is poorly understood.

In conclusion, while most of the actual estimates of elasticities of demand obtained are plausible, in view of their low precision and restricted applicability (being for part of the US market only over a short time period), it would appear unrealistic to use them in further quantitative analysis of the possible effects of changes in the world supply of medium-sized shrimp. The real elasticities of interest for such an analysis measure the effect on price of changes in supply, rather than the effect on quantity demanded of changes in price, as have been estimated here. In principle, the one set of elasticities can be estimated from the other, but the nature of the transformation between the two is such that it requires rather precise estimates of elasticities of demand.

However, the likely impacts on shrimp capture fisheries and aquaculture of the predicted increase in aquaculture production can be assessed on a qualitative basis.

5.5. Implications of Increased Aquaculture Production for Shrimp Production

Several predictions of aquaculture production levels have been published. The predicted quantities of aquaculture shrimp placed on the world wide market by 2000 AD range between 800,000 MT and 2,000,000 MT. The upper estimate can be discounted due to an over-estimate of the rate of increase of GNP and the failure to include limiting environmental and technological factors. Two different sources, using different methods of estimation, predict similar figures for the rate of increase of aquaculture production which result in approximately 1,000,000 MT being placed on the world market in 2000 AD, compared to 700,000 MT in 1992.

The relatively constant real prices in US$ of medium sized shrimp in all the main markets between 1980 and 1992 as aquaculture production increased three-fold world wide suggests that, unless a threshold in per capita consumption is reached, increased aquaculture production may have little affect on prices of medium sized shrimp, or prices in the large or small size categories. The increased aquaculture production may also not actually enter the main markets due to the recent emergence of markets for shrimp in many of the countries of origin.

If increased supply of medium sized shrimp does cause the price of medium sized shrimp to drop, the description of the US market and qualitative demand analysis based on the NMFS data suggests that, due to the large differences in price paid for the large and medium size categories and the different market segments they occupy, it is likely that the effect of a change in quantity supplied in one category will have only a small effect on the price of the other category, over the magnitude of the changes observed in the NMFS data. The medium and small size categories may interact more strongly due to the more similar market segments they occupy. The NMFS data suggests it is highly unlikely that there will be any large interaction between the large and small size categories.

Production costs for capture fisheries depend on the type of vessel, location of the fishery, and fishing operation involved (artisanal, semi-industrial or industrial). For artisanal fisheries, production cost per kilogram are approximately $US 0.31/kg, for semi-industrial fisheries costs are approximately US$ 2.8/kg and for industrial fisheries costs vary between US$ 5.8/kg and US$ 8.3/kg. Aquaculture costs depend on the level of intensity of production, with the costs of extensive production varying between US$ 1/kg and US$ 3/kg. Semi-intensive costs vary between US$ 3/kg and US$ 5/kg while intensive costs of production range from US$ 5/kg to US$ 7/kg.

Assuming static production costs, any reduction in the sales price of medium sized shrimp will force aquaculture production methods to switch away from the intensive farming methods, with production costs between US$ 5.00 and $ 7.00, towards the semi-intensive methods with lower production costs.

For capture fisheries, the implications are not so evident, due to the fact that production costs can vary according to operations and location of fishery. Furthermore these producers often obtain revenues from different sizes of shrimp as well as other marine fish species. One possibility may be a move towards the specific targeting of larger size categories of shrimp via a change in fishing techniques (gears) or the implementation of regulatory management measures such as closed seasons or areas.

Regarding the revenues of the shrimp production sector, a decrease in the price of medium shrimp will lead to a reduction in demand for small shrimp and thus lead to lower prices and quantity demanded for small shrimp. Similarly, although the effect will be smaller, the price and quantity demanded of large shrimp will also decline. These changes will result in loss of revenue for the production of small and large shrimp, and, due to the inelastic nature of demand for medium shrimp and current supply levels, will also cause a loss of revenue in the medium size category. Thus any reduction in price caused by increasing aquaculture production will reduce total revenues for the shrimp producing sector. How much the revenue of a specific country of origin will be affected depends on the preference traders in the main markets express for their product.

If market prices do fall, and production costs are stationary or rising, profit margins will narrow. The overall effect is likely to be a reduction in the employment opportunities within the sector. One hypothesis is that the marginal producers or operators will be the first to be affected by the economic constraints on the fishery. The precise effects on employment, in terms of the magnitude of change and specific sectors that will be affected, will be dependent on the nature of the individual fisheries.

A reduction in fleet size and an increase in individual catches leading to a decrease in cost per unit of production may occur. Alternatively, as profit margins decrease fishing effort may be increased, which hinders resource management. This is already being seen in the U.S.

6. Conclusions and recommendations

The principal aim of this study of production and markets was to predict how increased aquaculture production would impact on the revenues of both the shrimp aquaculture and capture fishery sectors. This aim has been met at least quantitatively, however it has proved very difficult to obtain quantitative estimates of own- and cross-price elasticities between the various size categories. This is due to the fact that for all of the main markets for shrimp world wide, consumption data disaggregated by size seem only to be available on public record for a limited sample of imports to the US. A quantitative demand analysis of this sample data was carried out, and plausible price elasticities were obtained. However, the price elasticity estimates were of too low a precision to transform into elasticities describing the affect of changing supply levels on price.

The information collected on the US market that was used to determine model specification for the quantitative demand analysis did allow qualitative estimates of the impact on the shrimp production sector of predicted levels of increased aquaculture production. This qualitative analysis indicated that unless there is a shift in the rate of change of consumer behaviour in the US, increased aquaculture production will have limited affect on the revenues of shrimp producers. If there is a shift in the US, then an increased supply of medium sized shrimp will result in a drop in price for medium sized shrimp and an accompanying reduction in both quantity demanded and price of the large and small size categories. The result would be a reduction in revenues for both the aquaculture and capture fishery shrimp producing sectors. Reductions in revenues would result in a shift from intensive to semi-intensive aquaculture production.

Based on these conclusions, the main recommendation of this study is that the management strategies for tropical shrimp resources should explicitly take into account the international market forces which affect them.

There is a major need for the identification and collection of key shrimp market data on an international level in order for these international market forces to be quantified. Shrimp of all size categories are internationally traded commodities. The widely dispersed shrimp producers (referring to shrimp producing countries, and encompassing operators in both the capture and aquaculture sectors) are therefore exposed to major uncertainties from both the resource and the markets. As a result, a producer will generally require data related to four major variables. On a national scale, information pertaining to the shrimp resource and the investment (labour and capital) associated with the resource exploitation or production is required. On an international level, information concerning the different markets is required together with the position of competitors.

The initiation of an information service specifically dealing with key shrimp market information would generate a statistical database which could be used for the permanent and objective evaluation of the international shrimp market in terms of supply and demand analyses. This system would allow subscriber states or individuals to compare their own activity with that of other producers, contributing to market transparency and allowing adjustments to be made in response to changes in supply and demand. In terms of shrimp resource management, this system would allow for the clearer formulation of policy directed at the sector.

With respect to the specific data requirements for disaggregated demand analyses, the following recommendations are drawn from the demand analyses. They indicate the type and level of data disaggregation which would, together with existing data, facilitate further work in this area.

(1) A record of the total quantity of imports entering the different markets with explicit reference to the quantity of each size category (size composition), species and country of origin.

(2) A record of inventories held in each market, with explicit reference to the size composition, country of origin and species.

(3) A record of domestic catches with explicit reference to size and species composition.

Apart from the requirement of robust own and cross-price elasticity estimates which would issue from a comprehensive demand analysis, the provision of realistic advice to resource managers and policy makers is also dependent upon the accuracy of biological and economic data from the fishery. The effectiveness of shrimp resource management or sectoral planning would be assisted by such a multi-disciplinary approach.
[1]

[1] Garcia, S. and Le Reste, L. 1981. Life cycles, dynamics, exploitation and management of coastal Penaeid shrimp stocks. FAO Fisheries Technical Paper 203.